Oregon Agricultural College
Experiment Station

REPORT OF THE

AGRICULTURAL EXPERIMENT STATION

1912-14

BY

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REPORT OF THE AGRICULTURAL EXPERIMENT STATION.

To the President of the College,

Sir: I have the honor to submit herewith the biennial report of the Oregon Experiment Station for the years 1912-13 and 1913-14 inclusive.

The work of the Station during the biennium has made good progress, and in some departments phenomenal results have been achieved.

Brief Review of Growth and Services of the Station.

Since this report concludes my services as Director of the Experiment Station, I beg your indulgence for this deviation in presenting a brief review of the progress of the Station, and the development of agriculture throughout the State during the past sixteen years, concurrent with my administration as Director of the Experiment Station.

In 1898 there were ten members of the Station staff; at this date there are forty-five. In 1898 there was the home Station with its five departments; now there are in addition to the home Station seven branch stations and some twelve cooperative experimental plats, with nine departments.

The total value of the agricultural products of the State in 1898 was less than thirty million dollars, while the total value of these products in 1913 was $139,505,328.

Dairying, during the past sixteen years, has shown a phenomenal growth in production, having increased in value from less than three million dollars to $18,425,000. Poultry has also shown a large increase in production; and the production of clover seed has grown from practically nothing to a crop valued at two million dollars.

Perhaps the most notable value of the Experiment Station work has been its influence for better agricultural and horticultural practices throughout the State, including its influence for better methods of handling live stock, especially the growing and fattening of swine.

The demonstration work of the Station, showing improved methods of moisture conservation, has been worth millions of dollars to the farmers in the drier sections of the State. These demonstrations, in fact, have shown that lean years may be largely averted in dry-farm districts.

The Experiment Station, in short, has pointed the way for a more successful agriculture, and has endeavored at all times to meet, to the best of its ability, every demand made upon it by this great and growing industry.

Report for Biennium 1912-14.

No changes in staff of any moment have occurred during the biennium.

In the spring of 1913 the Hood River Branch Experiment Station was organized, with Messrs. J. R. Winston, plant pathologist, C. C. Starring, horticulturist, and A. L. Lovett, entomologist. The work of this station has made excellent progress, and good results to the horticultural interests of the district have been achieved. Much preliminary work for the establishment of the Clatsop County branch experiment station has been accomplished; but it is as yet unorganized on account of the lack of proper building facilities.* The investigative work of this station will be along the lines of dairying, small fruits, and vegetable gardening, these being the principal agricultural industries to which the district seems to be especially adapted.

During the biennium the Station was able to cope with practically all of the important problems for which a pressing need for a more or less immediate solution was felt. It is thought, however, that further investigative work should be undertaken, at the earliest practicable opportunity, with control methods for fire blight. The Southern Oregon branch experiment station has undertaken a very extensive variety test with American and European pears with the hope of finding varieties of commercial value which are immune to this scourge, or with the hope of at least securing a vigorous, immune stock. In cooperation with this work a well-equipped laboratory should be maintained and placed in charge of a thoroughly trained scientist for conducting pathological experimental investigations.

One of the most pressing needs of the Station at this time is a fund for Station publications. There is a great deal of valuable accumulated experimental data that should be in the hands of the farmers, but the funds of the Station available for such purposes are not adequate to publish this information.

The acquirement of the 115 acres of additional land is proving very helpful to the work of the Station. This land is devoted mainly to livestock husbandry, principally to the experimental feeding of sheep and swine. Twenty acres is utilized as an experimental orchard, and twenty acres as a poultry breeding farm for egg production.

Facilities for Station work have been materially improved during the biennium. The remodeling of Science Hall has greatly increased the laboratory efficiency of the chemical department, and much-needed laboratory equipment has been acquired by other departments.

The following is submitted as a synopsis of departmental reports relating to the principal problems under investigation. Many facts in relation to this work have been published in the Biennial Crop Pest and Horticultural Report for the years 1911-12.

*For information concerning the progress of work at the Clatsop County branch experiment station, since this report was written, consult the Report of The John Jacob Astor Branch Experiment Station, Dec. 1914.

DIVISION OF HORTICULTURE.

ADAMS INVESTIGATIONS.

Project No. 1. Pollination. During the biennium a research bulletin, The Gross Morphology of the Apple, was issued, giving investigative data of work under the pollination project. A digest of this bulletin, which is one of a series of three on the Pollination of Pomaceous Fruits, may be briefly given, for the untechnical reader, as follows:

The major part of the edible portion of an apple or pear is of the same nature as is the tissue composing the stem. It may be considered as a hollowed-out stem which bears within it small fruits much resembling plums in structure. These findings, as set forth in the bulletin, are of interest and importance because they show that those conditions which modify stem structures, and only those, can modify the edible portion of the fruit, and that the latter is not changed directly by the influences of one or another kind of pollen.

Fruit-bud formation, especially with the Yellow Newtown apple, is being studied as a phase of the pollination problem. A complete study of the bud is being made from the time it begins to assume form up to the development of the fruit. The study is essential since there may arise and exist among the blooms on a tree abnormalities which would render them incapable of developing into fruit even though ideal conditions for pollination existed. It is estimated that eighty per cent of the work of this phase of the problem is completed. Comparisons of the developing buds in different positions on the tree indicate that differentiation into fruit or leaf buds takes place at different times. This confirms the conclusions of Goff. The investigation has shown that there is greater uniformity in this regard among the buds on spurs which have already borne fruit than there is among buds that are forming on young wood that has not borne fruit.

The study of the fibro-vascular system of the apple has been completed, and while other investigators, notably McAlpine of Australia, have contributed information on this subject, no record reveals the thoroughness and completeness of detail shown in the study made by this Station. Excellent progress has been made in the histological and cytological investigations on the pollen and ovules of the apple and pear.

Project No. 2. Irrigation Work with Apples. Conditions were unfavorable for this work during the summer of 1912, owing to an unusual amount of rain. A series of investigations in greenhouses, however, were undertaken, which are closely allied to the irrigation problem. Various amounts of water have been applied to potted dwarf pear trees, and a study of the effects not only on the external characters of the tree as to its growth, color, etc., was made, but a complete tissue study as well. (Second Biennial Crop Pest and Horticultural Report.)

New Projects. Two new projects have been accepted under the Adams Act. The first is concerned with pruning and the title suggested

is, "A Histological and Physiological Study of the Buds of Pomaceous Trees as Influenced by Pruning." A young orchard of 320 trees, with probably additional plantings, will be utilized for this investigation, and the Southern Oregon Station pruning blocks will be made available for supplemental data.

The second new problem is a study of "Critical Temperatures." Some important preliminary work has already been done, and with the dwarf trees, greenhouses, and cold-storage plant available for these studies, good results should be secured.

HATCH INVESTIGATIONS.

Most of the problems under this fund are supplemented with the Crop Pest Fund.

Problem No. 1. **Strawberry Variety Investigations.** Extensive experiments have been conducted for several years in the variety testing of strawberries. Altogether 196 varieties have been tested. Of these varieties eight may be said to have approached the ideal commercial standards established for this test. Two of these were the "Jucunda" and "Triomphe de Gand." These were among the early varieties introduced into Oregon and were grown for local use only. The other six varieties, namely, Wilson, Clark, Magoon, Marshall, Oregon, and Gold Dollar, are still being grown commercially. The Wilson, however, is gradually losing ground. This berry is of eastern origin. The Marshall, which commercially ranks fifth in the State, is of Massachusetts origin. The first two named are of European origin, and the Clark, Magoon, Oregon, and Gold Dollar originated in this State. These four for the past five years have given the best results at this Station. While many of the eastern varieties succeeded perhaps as well as in the East, they do not meet the commercial requirements of the West. It is possible that other eastern varieties may later be introduced that will prove superior to those tested. The Gold Dollar may be recommended as our most satisfactory early variety for the Oregon grower. It is soft in texture, however, and cannot be shipped to any considerable distance. The Magoon is the most popular main-season variety for the markets, but is a poor shipper and not desirable for canning. In some localities the Marshall takes the place of the Magoon. The Clark is the leading variety for shipping and canning, and the Wilson is an excellent canning variety for some of the stronger soils. The Oregon is a good variety for strictly local markets, having a very long fruiting season, and good quality, and is therefore valuable for the home garden. (Second Biennial Crop Pest and Horticultural Report.)

Problem No. 2. **Strawberry Breeding.** For several years this Station has been working on the strawberry-breeding problem. From a large number of seedlings, two or three of great promise have been selected. One of these seems to have embodied the qualities of the Magoon and the Clark. It is too early yet, however, to draw conclusions. The mother plants are very promising.

A pedigree study of strawberries has been completed which will be a distinctive contribution to the knowledge of plant breeding.

Problem No. 3. **Loganberry Investigations.** a. Loganberry Fertilizers. Fertilizing experiments with loganberries have been continued during the past season, but results do not warrant conclusions at this time.

b. Loganberry Pruning Investigations. A commercial planting of loganberries has been made in the new orchard tract where an investigation of various systems of pruning and training may be made. There is a great demand for this information among the growers of this State.

Problem No. 4. **Cherry-Breeding Investigations.** A large number of cherry seeds of known parentage has been secured. These seeds have been preserved and are planted with the hope of securing a goodly number of promising seedlings. There is a large field for this work in the State, and the purpose of the work is to determine the value of certain cherries for breeding stock and to produce commercial cherries of merit for the Pacific Coast.

Problem No. 5. **Apple-Breeding Investigations.** During the past six years apple seeds have been secured from the pollination experiments. These seeds are of known parentage. Seedlings obtained from these seeds have been grafted upon dwarf trees and will soon begin to fruit. The purpose of this investigation is to ascertain the value of certain apples for breeding, with the hope that valuable commercial varieties may be obtained.

Problem No. 6. **Prune-Breeding Investigations.** Some progress has been made in prune breeding, and it is contemplated to take up the pollination of the prune similar to the work conducted with the cherry for the past three years. In this way useful data should be secured to aid in the origination of a superior prune to that which is at present grown.

Problem No. 7. **Cover-Crop Investigations.** For this work between 500 and 600 dwarf apple trees on Doucin stocks have been set. These trees will be utilized in a series of experiments relating to cover crops, tillage, mulches, etc.

Problem No. 8. **Nut Variety Tests.** A large collection of walnuts and other nuts have been planted in the new orchard, and these, with those growing in the home orchard, should supply valuable data as to the best commercial varieties.

TRIAL GARDENS.

In cooperation with the Bureau of Plant Industry, a trial garden has been established to test out from time to time new introductions.

VEGETABLE INVESTIGATIONS.

Investigations in vegetable gardening are conducted jointly under the Hatch and Crop Pest Funds.

1. **Greenhouse Tomato Investigations.** This is a continuation of the work undertaken in 1912. The object sought is, first, to determine the best forcing varieties of tomatoes adapted to local conditions of good market requirements; second, to determine the efficiency and economic

value of artificial pollination; third, to make a study of the blossom clusters as to variation of varieties and its relation to the economic production of fruit. Two greenhouses, 30′x20′, have been devoted to this work. Both English and American varieties were grown, and the fruit produced was of a very high commercial standard. Table I gives the total number ounces of fruit produced between May 20 and June 20 inclusive, one row each of four plants:

Table I. Fruit Produced (number of ounces) by different varieties of Greenhouse tomatoes, under different methods of pollination, between May 20 and June 20.

Variety	Pollinated by hand	Pollinated by jarring	Not Pollinated
Stone	223½	162½	72½
	243½	142½	48½
Comet	266	239	114½
	186½	182	101
Jewel	169	144	132
	296½	192	104½
B. Best	189	.....	114
	346½	216½	.....
A-1	152½	.....	90½
A-E 3	132½	.....	92½
Best of All	179	.....	69
S. Earliana	325	280	....

2. Onion Investigations. Cooperative work with a number of growers has been undertaken to determine best cultural methods, use of fertilizers, and other factors relating to the industry.

3. Vegetable Type Selection. This is an investigation for the purpose of determining desirable types of vegetables for the canning industry. Seed will be secured of the most desirable types and distributed among commercial seed growers.

CROP PEST INVESTIGATIONS.

Problem No. 1. **Prune Fertilizer Investigations.** This is a cooperative experiment with two growers in Yamhill County and a large fertilizer firm. The purpose of the work is to secure data as to the influence of fertilizers on the trees, foliage, and fruit, and the effect upon the evaporating qualities of the fruit.

Problem No. 2. **Prune Standardization Investigations.** The purpose of this work is to effect a definite standard, or standards, for the commercially dried prune in the State. This will include a study of conditions influencing the fruit from the time it is grown until it reaches the consumer, including the technique of evaporation, sanitation, chemistry of the product, molds, insect infestation, processing, grading, and packing for market. The division of Horticulture will receive assistance in this investigation from the departments of Chemistry, Plant Pathology, and Entomology.

Problem No. 3. **Loganberry Investigations.** These investigations mainly relate to the commercial phases of the fruit, including the evaporated product and the juice.

a. Evaporation Investigations of the Loganberry. This work was done at Salem in the dryer of Mr. J. J. McDonald. An attempt has

been made to ascertain if the dried loganberry can be standardized, first, by investigating the time and methods of harvesting the product; second, the possibility of grading it, either in the field or at the evaporator; third, length of time required for evaporation; and fourth, the relation of temperature and air circulation to the product obtained.

It was found that the hard, ripe berries have the best quality and weight; that under average conditions berries should not be picked after noon and preferably not after 10 a. m. There is a very close relation between the dried weight obtained and the general condition of the product on the one hand and the condition in which the berries are brought to the evaporator, on the other. Berries picked after 10 a. m. are apt to be soft, to melt down, caramel, and scorch more than those which are picked in the early morning. It was found that the length of time given for evaporation was too long—many growers using 30 to 40 hours. The best results were obtained by drying the berries 16 hours and second best by drying 13 hours. The general practice is to run the temperature too low at first, and this condition, coupled with lack of grading in many cases, causes a loss of 2 pounds to the crate, and also gives a large percentage of scorched fruit. It was found better to start the temperature at about 130 degrees and conclude with a temperature of 150 degrees.

b. Loganberry-Juice Investigations. This study was undertaken to determine the commercial value of this product. It was found that by crude methods 75 per cent of juice could be obtained. It was also found that there is a very close relation between the amount of juice obtained and the length of time the berries stand before being pressed. Many formulas were used; but for home use, one part of sugar to three parts of juice by weight is recommended, the juice to be heated to the boiling point and bottled immediately in sterilized bottles. For commercial purposes, ten pounds of sugar to one gallon of juice is the formula suggested. Very ripe berries put up at once give the best aroma and flavor; second best are the dead-ripe berries, which are allowed to remain for twenty-four hours; third best are the hard ripe berries, and the least desirable are the green berries. The ripe berries give the largest percentage of juice. Chemical analysis shows that dead-ripe berries run from 1.78 per cent to 1.88 per cent acidity, while the hard berries and those which are unripe give more than 2 per cent acid; that the ripe berries run from 6.4 per cent to 6.46 per cent in sugar content; that the hard-ripe berries run from 4.91 per cent and the decidedly under-ripe run only 3.5 per cent sugar.

Problem No. 4. **Fruit-Pit Investigations.** Work in this investigation for the past two years has been conducted at the Wallace orchard, Salem, and the Meeker orchard, Corvallis, and also in cooperation with the department of Plant Pathology, at the Hood River branch station. Various fertilizers and different cultural methods have been tried, and in the Meeker orchard toxic substances have been fed to the branches of trees. Results so far do not warrant conclusions.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY.

ADAMS INVESTIGATIONS.

Project No. 1. Cherry Gummosis. This work has been continued along the same lines as heretofore, since it has been necessary thoroughly to check up and confirm all previous work. A great deal of culture work has been done, as well as inoculation work. Similar troubles have been found upon other drupaceous hosts which are now being investigated, and several strains of the organism have been found. Survey work in certain orchards established the fact that the Lambert cherry suffers less from the disease than does the Bing or the Royal Ann varieties, which seem to differ but little in susceptibility. It was also proved that the Mazzard type of seedling is in general resistant to the disease. Limb grafting on this stock is recommended for the susceptible varieties. During the winter the strains of bacteria isolated the previous season were subjected to sufficient cultural study to indicate that the majority were similar to that isolated by Mr. Griffin—one strain capable of inducing gum-flow differed and was called "strain 2." Lack of incubator facilities resulted in the postponing of the critical work on the physiological and cultural characteristics of the bacteria. During the spring, inoculations and isolation work was done with the same results as in the previous year. From various sources new bacterial strains were isolated, most of them similar to **B. cerasus,** but a few like "strain 2." Late in the spring several apparently saprophytic strains were isolated from lesions, while still later all attempts to secure organisms from the advanced margins of cankers failed, even where the bacterial structures could be found in microscopic sections. This seems to indicate that the bacteria die during the summer in many, at least, of the cankers. In the case of the inoculations, the earliest ones progressed the farthest, but in all cases the spread seemed to be checked by cambial activity before cankers of any size were formed. Gum exudation took place.

Histological study of fresh material was most carefully carried on with specimens of diseased branches and trunks from many sources. Again and again the presence of bacteria was demonstrated in the lesions even in tissues beyond the advancing margin of the discoloration in rapidly spreading cankers, providing rather convincing support for the theory that the disease called "gummosis" is due to their presence. The bacteria seem to advance largely through the phloem tissues in the earlier part of the season, but later this advance seems to be checked by the starting of cambian activity and wound-cork formation in this region, though the lesion may still extend itself to some extent in the outer cortical region until there too wound-cork is formed which limits the season's growth.

Observations on the inoculations of 1912 indicate that no spreading of the lesions produced in that way took place during the past season. This was also true of many natural cankers under observation, though

in some cases there appeared to have been a spreading from some of the old cankers. This seems to lead to the conclusion that the bacteria live over in but few of the cankers from one season to the next.

Cutting out of the diseased tissue found on certain trees early in the season seems to have resulted in a control of the advance of the disease on those trees during this season, accompanied by a rapid callus-formation. Many trees were observed, however, where infections not evident in 1912 have advanced during the succeeding spring at a very rapid pace, giving no external indication of the extent of the injury till new wood began to be formed around the dead area.

Project No. 2. Apple Tree Anthracnose. The work on this project has been largely a continuation of previous work. It seemed desirable to confirm all previous results obtained and to carry on a large series of inoculations. This work is in preparation at the present time. This disease has been found on the pear and some study of this made. The perfect stage was also found upon the pear. The disease, as it occurs upon quince, has received some attention. The study of a fruit rot and twig blight is in process. Recently a large series of cultures have been obtained, some from the perfect stage on both apples and Winter Nelis pear, and the conidial stage from apple branches, apple fruit, pear seedlings, Winter Nelis branches, quince fruit and the twigs. It is proposed to carry on a large series of inoculations on apple and pear to determine absolutely whether the forms are all the same.

HATCH INVESTIGATIONS.

Only a small allotment from the Hatch Fund has been available during the year by this department. This has been used entirely for salaries and has been considered as supplementary to Adams and Crop Pest work.

CROP PEST INVESTIGATIONS.

No. 1. Potato Diseases. Potato diseases have received special attention. Several diseases have been under observation, including certain diseases caused by a species of Fusarium, the Silver Scurf,—a disease to date not reported in the west,—Rhizoctonia, scab, etc. The principal work has been on the late blight, which, in the fall of 1912, was very serious in the State and caused a great deal of damage. Important observations made on this disease, developed the fact that it also attacks tomatoes, producing rot of the fruit as well as a blight of the leaves.

During the season of 1913 spraying experiments for the control of the blight have been conducted at Clatskanie on the 16-acre field belonging to John Cheldelin. A similar experiment was also conducted by John Miller in an adjoining field of twenty-two acres. Bordeaux mixture was used. The first application was made July 11, the second, Aug. 7, and the third the later part of August. The 4-4-50 formula was used in the first two sprayings, and 6-6-50 in the last. The results of the spraying experiment were very conclusive, since the blight appeared in the fields

early in September, and the plants which had not been sprayed were soon completely destroyed, while those which were sprayed were still alive and vigorous. Many potatoes were found rotting in the ground at picking time on the unsprayed plots, but such tubers were very rare where spraying had been conducted.

No. 2. Brown Rot of Prunes. Spraying experiments were conducted in the orchard by Mr. Z. L. Chamberlain at Newberg. The crop was very light in this orchard and very little brown rot developed, so the results of the experiment were inconclusive, but indicated the benefit of spraying.

No. 3. Mushroom Root Rot. Considerable field work on this disease was conducted. The disease was found upon the apple, cherry, peach, prune, rose, oak, walnut, etc. Pure cultures were obtained from many of these hosts. Some study was also started on cultures originating from mushrooms on fir, maple, etc., to determine whether the fungus which attacks the fruit trees is the same as that which occurs native upon forest trees. Some inoculation work has also been done. Observations on combative measures show that the recovery from attacks of this disease have been made in well-authenticated instances by surgical methods on apple trees accompanied by the exposure of the base of the trunk and main roots.

No. 4. Rust of Pear and Quince. A rust of pear has occasionally been reported from Oregon for a number of years past, though it is usually not considered serious. This was reported for the first time on quince in the summer of 1912. In this instance nearly 50 per cent of certain trees were affected. In the spring of 1913 this disease broke out in epidemic form and caused a great deal of damage to pear and quince trees. It very rarely occurs upon the apple. Studies of this disease seem to indicate that it is probably the same as the one which occurs upon native pomaceous hosts, notably service berry and hawthorn. It has been shown that the rust which occurs upon the native hosts is connected with a rust which occurs upon cedar. No proof has as yet been found that the pear and quince are genetically connected with cedar rust, but it is thought that this is true.

No. 5. Crown Gall. Experiments have been conducted during the past biennium on crown gall of peaches at Ashland. This work has been an attempt to control crown gall after it gets a start in an orchard. While it is too early to obtain final results, indications are that the work was more or less successful. An extensive experiment is being conducted in cooperation with the Oregon Nursery Company at Orenco. This consists in comparisons of the growth of trees which are affected with crown gall and hairy root at planting time, with others which are healthy.

DEPARTMENT OF ENTOMOLOGY.

ADAMS INVESTIGATIONS.

Project No. 1. Scolytidae infesting the Douglas Fir. Pseudotsuga taxifolia (Pow) Britt. The following general phases of the work have taken up most of the time allotted to this work:

1. Present status of this or related problems—a review of all the literature thereon.
2. A systematic study of the group. The accumulation of a collection.
3. A study of forestry and lumbering methods, and their possible bearing on the problem.
4. The number of species concerned. Their distribution in Oregon.
5. Effect upon the tree; part attacked, symptoms of attack.
6. Life-history and biology.

Project No. 2. Red Spider Investigations. Work in color variations completed. Systematic work pursued. Value of the characters of the genital armature discovered and used. Four new species, all of economic importance, found. Three described. Key to males published. Slides from Washington examined and notes and drawings made. Work on natural enemies continued. Several new natural enemies found, including a gamasid mite, a Bdellid, a species of Rhyncholophus. Notes and drawings made of previously known natural enemies. Some of the stages in the life-histories of natural enemies determined. Geographical distribution work started. Map of United States made for showing distribution of each species. Drawings made of several species of red spiders. Notes on seasonal history continued, also those on habits. Control measures tried as follows: Fumigation, evaporation of sulfur, spraying with several kinds of sprays against spiders on hops, pears, violets, tomatoes, and melons, and some other plants. Cause of infestation and methods of its prevention studied. Nature of injury studied. Samples obtained, photographed, and mounted. (Station Bulletin 121.)

HATCH INVESTIGATIONS.

No. 1. Introduction of Beneficial Insects into Oregon. Interesting data of more or less value have been secured in connection with the Coccinellidae (Ladybird beetles). Notes on migration and hibernation were made and the life-histories of two different species have been worked out. Statistics have been takn on the abundance of different species, as well as upon the different insects that serve as hosts of these enemies. **Megilla maculata** (the common eastern Ladybird beetle), a very abundant species in the East, has been introduced and is being reared in confinement. Specimens will be liberated when they become acclimated. A study of some new enemies of stored grain has been made, Recently a shipment of codling moth parasites (**Calliephialtes messor** Graves) from California has been received, and an effort will be made to establish this insect in Oregon.

CROP PEST INVESTIGATIONS.

The Shot Hole Borer (Xyleborus dispar Fab), **Brown Apple Aphis (Aphis sorbi** Kal) and the **Strawberry Root Weevil (Otiorhynchus ovatus** Linn.) were selected for primary investigations. In addition to these, as time and circumstances would permit, a number of less important insects have been studied. The results of the investigations, supplemented by other data previously in the department files, have been published in the Biennial Crop Pest and Horticultural Report for 1911-12.

A number of minor problems studied during the past two years are now being studied as major problems and it is the intention of the department to take the following problems and work them out one by one:

1. The introduction of beneficial insects into Oregon.
2. Combination sprays: To determine practicability of combining lime-sulfur with arsenate of lead, arsenite of zinc, and "Black Leaf-40" for control of insect pests and plant diseases, in cooperation with the department of Plant Pathology.
3. Life-history and control methods of the Woolly Apple Aphis (**Eriosoma lanigera**).
4. Life-history and control methods of the Fruit Tree Leaf Beetle (**Synota** Albida).
5. Life-history and control methods of the Bud Moth (**Tmetocera ocellana**).
6. Life-history and control methods of the Cherry Fruit Fly (**Rhagoletis cingulata**).
7. Vetch and Pea Aphis (**Macrosiphum pisi**).
8. Continuation of studies on the control of the Strawberry Root Weevil (**Otiorhynchus ovatus**).
9. Life-history and control (preliminary) of Strawberry Root Miner (**Aristotellia sp.**)
10. Continuation of studies of poison sprays for the control of the Currant Fruit Fly (**Epochra canadensis**).
11. Life-history studies and control measures of the Cucumber Beetle (**Diabrotica soror.**)
12. Studies in the life-history and control of the Clover and Alfalfa insects.

Insecticide and Fungicide Investigations. In cooperation with the department of Botany and Plant Pathology.

The following are the summarized notes of results of this investigation:

1. Lime-sulfur 29.5 degrees Be (1-30) plus acid arsenate of lead, 2 pounds to 50 gallons, did not cause any more spray injury to foliage and fruit than did the lime-sulfur and neutral (spray injury quite bad on Newtown and Ben Davis). Injured fruit worst on south side of trees and in direct rays of sun.

2. Lime-sulfur 29.5 degrees Be (1-30) plus arsenite of zinc, 1 pound to 50 gallons, (two different brands) caused very little injury to foliage

and except in the case of Ben Davis did not cause any more injury to the fruit than was found on unsprayed trees. (Ben Davis suffered badly.) The injured fruit on these trees was worse on south side of tree.

3. Injured apples similar to those on the sprayed trees could occasionally be found on unsprayed trees in the check plots, but the difference in percentage was so great as to warrant the conclusion that the injury on the sprayed trees was in some way due to the action of the spray.

In 1912 a series of experiments was started upon the decomposition of combined sprays when allowed to stand. The materials in each case were kept in corked bottles and examined from time to time during the following year. Apparently no further change occurred and each combination retained its characteristic odor. An examination June 1, 1913, gave the same conditions, and tests for the insecticidal value showed them to be apparently as efficient as freshly prepared materials.

The arsenates of lead used in these experiments were especially prepared by the Station chemical department and were theoretically pure.

The fungicidal value of the following experiments was not considered.

To determine the effect upon apple foliage of the above chemicals alone and in combination, a series of experiments was conducted as follows: In a block of 20 Newtown apple trees, each tree was used for one spray. Applications made June 16, 1913.

Ex. No.		
1.	Arsenate of lead (acid)	8 lb. to 100 gals. water
2.	" " " "	4 " " " " "
3.	" " " "	2 " " " " "
4.	" " " (non-acid)	8 " " " " "
5.	" " " "	4 " " " " "
6.	" " " "	2 " " " " "
7.	Arsenate of zinc	8 " " " " "
8.	" " "	4 " " " " "
9.	" " "	2 " " " " "
10.	Arsenate of lead (acid)	8 " " " " lime-sulfur 1-30
11.	" " " "	4 " " " " " " "
12.	" " " "	2 " " " " " " "
13.	" " " (non-acid)	8 " " " " " " "
14.	" " " "	4 " " " " " " "
15.	" " " "	2 " " " " " " "
16.	Arsenate of zinc	8 " " " " " " "
17.	" " "	4 " " " " " " "
18.	" " "	2 " " " " " " "
19.	Water without chemicals	
20.	Lime-sulfur, 30.5 degrees Be. 1-30	

These trees had not been previously sprayed, and the leaves were more or less affected with scab. The orchard had only been cultivated once and therefore was in prime condition to give results in an experiment of this character. The two days following varied from rain to sunshine, mostly rain.

Summary of Results.

Lime-sulfur plus arsenite of zinc; lime sulfur plus arenate of lead (acid); and lime-sulfur plus arsenate of lead (non-acid); in all strengths caused serious burning. If anything, the non-acid injury was slightly the worst. Lime-sulfur caused considerable injury, but not one-half as much as in the combination sprays.

Arsenite of zinc alone and in all strengths caused considerable burning. The burning was different, however, from that of the combination

and lime-sulfur sprayed trees. With the combination sprays, the entire leaf was destroyed or else the injury covered a distinct portion, all parts of which were discolored. Scab spots on the leaves appeared black, ordinary leaf tissue brown.

With the arsenite of zinc, only the scab spots were injured. In a few cases entire leaves were blackened or browned. The majority of the injured leaves were spotted with injury. Each one of these spots was determined to be the seat of germination of a scab spore. The leaf tissue, between and surrounding these spots, did not appear to be injured.

Arsenate of lead (acid) and arsenate of lead (non-acid) did not cause injury in any case when used alone. In experiments with arsenite of zinc, etc., where injury did occur, the injury did not begin to show up badly for about five days, when suddenly, over night, it appeared at its worst. The check trees, sprayed with water, did not show injury.

As soon as the injury on trees sprayed with arsenate of lead (non-acid) became apparent, checks were made on trees 10, 12, 13, 15, 16, and 18. The utmost care was used in these applications, and as the same injury occurred a second time, we must conclude that even with the purest of chemicals, lime-sulfur plus arsenate of lead is not a stable spray under northwest conditions.

The controlling factors are yet to be determined. Two other experiments for the control of the codling moth have not yet been finished. But in one of these, lime-sulfur plus arsenates of lead (acid and non-acid), and arsenite of zinc, did not cause more than slight injury at the first application. The second application on June 30 caused serious injury. Therefore we may say that the above combination sprays are safe for the calyx spray, but are unsafe at the time of the second codling moth spray.

Recent Insecticide Investigations.

1. To find the value of lime-sulfur as a stomach poison.
2. To find the value of arsenate of lead (acid) as a stomach poison.
3. To find the value of arsenate of lead (non-acid) as a stomach poison.
4. To find the value of arsenite of zinc as a stomach poison.
5. To find the value of arsenate of lead (acid) plus lime-sulfur as a stomach poison.
6. To find the value of arsenate of lead (non-acid) plus lime-sulfur as a stomach poison.
7. To find the value of arsenite of lead as a stomach poison.

The chemicals used were secured from the same source as those used in the spray-injury experiments.

Larvae of the tent caterpillars, **Lalacasoma erosa** and **Malacasoma pluvialis,** were used in these experiments and were placed on sprayed twigs in the open part of the insectary. Newspapers were placed under each of the twigs to catch the dead larvae and every experiment kept separate from the rest.

Summary of Results.

Arsenite of zinc is a quicker-acting poison than arsenate of lead, acid or non-acid, and remains in suspension much better. Acid arsenate of lead is a quicker-acting poison than the non-acid and remains in suspension better. Non-acid arsenate of lead is slow in its action, but is satisfactory in that death finally occurs.

Lime-sulfur in the experiments conducted has not proved to have much value as a stomach poison. Lime-sulfur with arsenicals seems to retard to a more or less extent the action of the poison and it is possible for larvae to feed on foliage sprayed with weak strengths of lime-sulfur plus arsenate of lead and recover, if transferred to fresh foliage within a few days.

Very young caterpillars placed on twigs freshly sprayed with lime-sulfur 1-30 died within two or three days, but as they did not feed, death must have resulted from the gases given off. Very young caterpillars placed on twigs that had been sprayed with lime-sulfur 1-30 and allowed to stand, refused to eat and finally died from starvation. Half-grown larvae placed on twigs sprayed with lime-sulfur did not feed as did the larvae on unsprayed twigs, but did eat to some extent. After two weeks on lime-sulfur sprayed twigs, they were transferred to freshly sprayed leaves and finally matured, pupated, and emerged in the adult stage.

Lime-sulfur probably acts as a repellent to biting insects in the same way that Bordeaux does against the potato flea beetles. Lime sprinkled or sprayed on the foliage in the same proportions as found in a certain amount of lime-sulfur has no effect.

DEPARTMENT OF CHEMISTRY.

ADAMS INVESTIGATIONS.

Hop Investigations. A study was made of the chemical changes in the hop due to "sulfuring" (the common treatment with sulfur dioxide fumes). The results obtained from the investigations showed:

1. That there is nothing to indicate that sulfuring in the bleaching process affects the bitter resins. The resin of the "sulfured" hop contains no sulfur.
2. That the sulfur dioxide does not combine with the essential oil of the hop.
3. That the "unsulfured" hop contains sulfur in the sulphate form but no sulfur which is volatile by the ordinary steam distillation.
4. That different samples of "sulfured" hops contain different amounts of sulfur, both total and volatile with steam. There seems to be no definite proportion between the volatile sulfur and the total sulfur.
5. That the amount of sulfur present in the unsulfured Oregon hop is practically constant.

6. That the analytical methods which have been in use for the estimation of the amount of "sulfuring" are unreliable.
7. Methods for determining quantitatively the different forms in which sulfur is found in the "sulfured" hop have been worked out.

The hop seed when ground yields an ether extract amounting to approximately 25 per cent of its weight. This extract contains a drying oil which resembles linseed oil in some of its properties.

An experiment designed to show the chemical changes taking place in the hop during storage has been carried on since October 31, 1912. Samples have been taken every two months until the present time. All the samples taken have been analyzed. The results as yet are incomplete.

Chemical Spray Investigations. The work on this project during the biennium has been a study of the different arsenates of lead. The most significant results of the work completed thus far are as follows:

1. Lead hydrogen arsenate (lead "acid" arsenate) has been prepared in the pure form. The work done indicates that this compound has not been successfully prepared in its pure state previous to this time.
2. All attempts to prepare ortho arsenate (neutral lead arsenate) have failed. In fact, the work shows that this compound, which has been thought by previous investigators to be one of the constituents of commercial lead arsenate, does not occur in this material.
3. A new arsenate of lead has been prepared. This is a basic arsenate which evidently is the principal constituent of the commercial "neutral" arsenate of lead.
4. A pure pyro arsenate of lead has been prepared.
5. An analytical method for determining the amount of lead hydrogen arsenate (lead "acid" arsenate) in mixtures of this compound with the basic lead arsenate, has been developed. This method is a decided step toward the accurate valuation of commercial samples.
6. In cooperation with the department of Entomology, experiments have been carried out on the actual insecticidal value of the different lead arsenates. The results obtained show that lead hydrogen arsenate has much greater killing powers than the basic arsenate.

Soil Bacteriological Investigations. This work has been carried on cooperatively with the department of Bacteriology. Nearly 500 chemical determinations have been made in this work. Six distinct types of Oregon soil have been studied. The work thus far has been a comparative study of the ammonifying, nitrifying, and denitrifying efficiency of the different types and the effect of the application of lime upon these powers.

Lime seems to have a marked effect upon the soils of Western Oregon, showing a marked increase in ammonifying and nitrifying efficiency. The effect on the soils of Eastern Oregon is not so noticeable.

Incubation Investigations. A small amount of work has been done, the results of which are as yet incomplete.

HATCH INVESTIGATIONS.

Investigation of the Composition of Oregon Forage Crops and Grains. A small amount of work has been done. The arrangement of the work of the laboratory was such that not much time could be devoted to this subject.

Soil Analysis. This has been a continuation of the work already in progress. Representative samples of the different types of soil occurring in the Hood River Valley were analyzed. These samples were selected by the experts who made the soil survey of that county for the Bureau of Soils, U. S. department of Agriculture. The analyses of these samples revealed a grave nitrogen deficiency in many of the soils of that region. Some deficiencies in potash and lime were also found.

Fertilizer Control Work. Samples of simple and mixed materials have been collected from the market and analyzed. Practically no violation of the State fertilizer law has been found. The commercial brands of fertilizers now sold on the Oregon market have been licensed in accordance with the law.

Miscellaneous Work. This includes the various routine determinations which have been made for residents of the State. The samples examined consist mostly of feeding stuffs, mineral waters, and insecticides and fungicides. Practically all of the different brands of arsenate of lead, arsenite of zinc, and lime-sulfur solution now being sold on the market have been analyzed.

DEPARTMENT OF BACTERIOLOGY.

ADAMS INVESTIGATIONS.

A Study of the Activities of Oregon Soil Bacteria. The preliminary work has been done in this study and considerable time has been spent on the various problems of nitrogen fixation, ammonification, denitrification, and cellulose digestion. In cooperation with the department of Chemistry 500 routine determinations have been made.

HATCH INVESTIGATIONS.

During the spring, summer, and fall of 1912, records show that 315 cultures of bacteria for the inoculation of legumes were sent out by the department. This was a growth of over 100 per cent in advance of the year preceding. During the spring and summer of 1913, 620 cultures of this class have been sent out, showing an increase of 97 per cent over the culture distribution of 1912. Culture blanks were sent out in October, 1912, requesting that the results obtained, whether favorable or unfavor-

able, be reported to this office and a careful compilation of the reports sent in shows that direct benefit was derived in 69 per cent of the instances where the culture was used. This record is particularly good when it is considered that the soils in Western Oregon tend toward acid reaction, which condition is unfavorable both to the growth of such a crop as alfalfa and also to the micro-organisms necessary to inoculate the roots of the crop. In the eastern part of the State, in the semi-arid region, soil conditions are decidedly dry and there is considerable alkalinity. Both of these conditions; namely, dessication and the presence of an abnormal amount of acid or alkaline salts, are unfavorable to the life and activities of the seed inoculation organism, **B. vadicicola.**

Table II indicates the number of cultures sent out for each crop:

Table II. Number of Cultures of Bacteria for Inoculating Legume Sent Out for Each Crop, with Aggregate Acreage.

Crop	No. of Cultures	Acreage in Aggregate
Alfalfa	164	1008.50
Red clover	51	407.75
Alsike clover	5	15.75
White clover	3	4.00
Vetch	18	232.50
Garden peas	34	65.25
Garden beans	33	36.00
Canada field peas	4	13.25
Soy beans	2	1.25

Miscellaneous Investigations and Examinations. The general routine work of the department shows a large increase. Many specimens have been examined, consisting of water samples, submitted for sanitary examination by farmers and other citizens, human blood, chickens, faecal matter, hog tissue, milk and cream, pus, sputum, swabs, human tissue, human urine, vomitus, dog brains, turkeys, insect larvae, and bread crumbs.

A good deal of work of a laboratory nature has been done with chickens and other poultry. Avian tuberculosis is the disease most often met with in this connection. Certain lesions of peculiar and rather abnormal character have been found in chickens infected with this disease in this State. Not always are the tubercules fatter or calcarous, but sometimes they prove to be less firm, although the tissues do not show traces of breaking down, and are hardly at all fatty. Lesions of this character appear to be found more often in the messentery. In these cases the liver, which ordinarily is the tissue first attacked, seems to be comparatively free.

An investigation will be made of eggs from the College flocks and from flocks in the vicinity for the detection of possible carriers of the disease of young chickens known as "White Diarrhoea," the infecting form being **B. pullorum.** It is also desirable to examine the ovaries of possibly infected hens. Already a number of such birds have been found, and it is thought a decided benefit can be rendered to the poultry industry by such examination for the production of uninfected stock.

DEPARTMENT OF ANIMAL HUSBANDRY.

HATCH AND STATE INVESTIGATIONS.

Experimental Feeding of Swine.

The experimental work with swine has been fattening for market; testing the efficiency of the self-feeder for that purpose; and testing the relative efficiency of tankage and skim milk as adjuncts to barley. Equal nutrients rather than financial values from these two sources, were tried out in determining the requirements for producing 100 pounds of pork.

Experiment 1. Tankage vs. Skim Milk as supplemental Feeds. Initial weight, Lot 1, 675 pounds; Lot 2, 635 pounds. Weight at conclusion of experiment, Lot 1, 1344 pounds; Lot 2, 1243 pounds. Feed consumed for 100 pounds gain, Lot 1, 271.9 pounds barley and 631 pounds skim milk; Lot 2, 331.1 pounds barley and 35.11 pounds tankage. Cost of 100 pounds gain, Lot 2, $5.84. Value of skim milk for each 100 pounds gain in Lot 1, as compared with Lot 2, $28.29.

In the above table barley is estimated at 1½ cents a pound, tankage at 2½ cents. It will be noted that the cost of gains are low considering the cost of feed. On barley alone and assuming 450 pounds barley required for each 100 pounds gain, the cost of this gain would have been at least 90 cents greater, in comparison with which prices skim milk returns a value of 28.2 cents for each cwt.

Experiment 2. Self-Feeder vs. Hand-Fed. Lot 1, Self-Feeder, Lot 2, Hand-Fed. Feed required for 100 pounds gain, Lot 1, 512.2 pounds and Lot 2, 488.3 pounds.

Both lots received the same ration; viz., crushed wheat 5 parts, shorts 4 parts, tankage 1 part. The ration fed to the hand-fed was soaked twelve hours prior to feeding; that of the self-feeder was fed dry.

Experiment 3. Self-Feeder vs. Hand-Fed. In the second trial of the self-feeder a marked advantage in favor of the self-feeder lot was obtained. Since, however, the self-feeder ration was fed dry and the hand-fed ration was soaked twelve hours before feeding, a check on the effect of soaking is to be run in a subsequent experiment. Lot 1, hand-fed, Lot 2, self-feeder; feed for 100 pounds gain—Lot 1, 536.7; Lot 2, 417.9 pounds.

From the above summary it will be seen that the self-feeder lot ate more feed daily and gained more rapidly at a small cost of nutrients than did the hand-fed lot.

Experiment 4. An Experiment to determine the Cost of Production. Two Duroc Jersey sows, with nine seven-day-old pigs each, were purchased. The sows were estimated at $20.00 each, the pigs at $3.00 each. This is assuming an abnormally high birth cost, but in lieu of a more accurate one, this is accepted, it being the price at which the pigs were purchased. The fifteen pigs grown consumed from April 1 to August 15, 3,436.3 pounds of mill feed and the sows during the time of suckling the pigs consumed 1220 pounds, representing a total value of $122.68 or

$8.74 for each hundred pounds of live weight of pigs. The ration consisted of wheat 5 parts, shorts 4 parts, and tankage 1 part. Tankage was estimated at $45.00 a ton, wheat $26.00, and shorts $30.00. Assuming a birth cost of $1.50 each for the pigs, the cost of production would be reduced to $6.81 for each hundred pounds.

Experiments with Sheep.

Experiment 1. To determine the Practicability of utilizing cull Ewes for the Production of early Market Lambs. Twenty cull ewes, some of them quite old, were selected. These were fed during the winter, in an open yard with shed. Owing to a total lack of pasture large quantities of hay and grain were required to maintain the ewes in good condition. The lambs came at irregular intervals and so were marketed at various times. Thirteen were sold at Easter time as hot-house lambs and brought a good price. The remaining seven were not sold until the end of June. Those sold for the Easter trade averaged about 40 pounds live weight, while those sold in June averaged over 70 pounds, but they brought approximately the same price a head. Two of the ewes died during the experiment, but considering age and character of the stock such a loss could not be considered abnormal.

Cost of ewes, $82.42; cost of feed, $149.68. Sale of ewes, lambs and wool, $191.51. Loss, $40.59.

Experiment 2. Shelter Test. The object of this test was to determine the advisability of keeping lambs under shelter during the winter. Eleven lambs were selected from the College flock and divided into uniform lots by the "pairing" system. The one odd lamb (Cotswold) was placed in the inside pen. Lot 1 were allowed the run of the entire farm and were fed in trough and racks in the open field. Lot 2 was kept in a shed with access to a small outside yard well bedded with straw. With the exception of the odd lamb in the pen, all the lambs were thrifty.

Average gain for each lamb during the experimental period from December 3 to March 4, Lot 1, 27.75 pounds; Lot 2, 23.25 pounds.

While this test is too small to justify any definite conclusions, the results indicate that from the standpoint of the rate and economy of gain, those under shelter did much better during the rainy season, but that the best results of all were obtained from those outside during the good weather.

POULTRY HUSBANDRY DEPARTMENT.

ADAMS INVESTIGATIONS.

Incubation Investigations. The problems of incubation and rearing of the chicks are thought to be more intricate and difficult than any other in poultry keeping. The main purpose of this investigation is to learn, if possible, the cause of the loss from eggs that fail to hatch and the mortality of chicks. In cooperation with the department of Chemistry much interesting experimental data have been secured. Experiments on

the influence of different degrees of humidity, both as it relates to the incubation of the egg and the vigor and subsequent growth of the chick, have brought out some important results, both from the practical and chemical viewpoint. It has been shown that the humidity surrounding the eggs during incubation has a highly important function to perform. This, taken in connection with ventilation of the incubator and the supply of oxygen, is probably the factor to be reckoned with in solving the problem of losses in connection with the hatching of chickens. Considerable data have been secured relating to the amount of carbon dioxide in incubators and under hens, and as to its function in incubation. A series of determinations has been made showing the effect of different degrees of humidity and ventilation on the chemical composition of the chick.

HATCH AND STATE INVESTIGATIONS.

Under the funds of these investigations, the work in breeding for high egg production has been continued. The results of this breeding work have been very encouraging and show conclusively that it is possible by selective breeding to increase egg production. Records since the work commenced, some five years ago, show an increase in yield each year. There is now a good-sized flock of layers with pedigrees dating back three years, and in some cases four years, from stock that laid 200 eggs a year or more.

The purpose of the work was in the first place to determine, or demonstrate, whether or not high egg-laying is transmitted from parents to offspring, and if so transmitted, what method of breeding should be followed by practical poultry breeders to secure the benefit of a higher egg yield.

In this work there has been used each year a flock of some 400 pullets and hens of two breeds of chickens, the Barred Plymouth Rocks and the White Leghorns. These breeds have been bred separately and breeding stock has been selected from them on the basis of their trap-nested egg records, covering from one to four years.

Another method has been followed, that of crossing the two breeds mentioned to determine what effect crossing has on egg yield and on vigor, and to ascertain whether high egg yield could not be more quickly achieved by developing a new strain or variety.

In connection with this primary object, it is thought that there is a demand for a type of fowls having, in the first place, high egg-laying as a fixed characteristic, and, in the second place, better meat qualities than the Leghorn. The Leghorn, on the one hand, is not a good market bird, and the Plymouth Rock, on the other hand, while a good market fowl, is too large for the general consumer. It is thought possible to add a little to the meat qualities of the Leghorn as well as to its egg production. With a type of chickens weighing from four to five pounds, the consumption of poultry will be very greatly increased. Results show that this ideal is within reach; that is, the egg records show a much

higher yield than the average of either the original Plymouth Rocks or the Leghorns, while the meat quality is also such as better to meet the needs of the great body of consumers.

DEPARTMENT OF AGRONOMY.

HATCH AND STATE INVESTIGATIONS.

Rotation Experiments.

1. Rotation of soil crops for the continuous production of green feed throughout the year under Western Oregon conditions.

Results show, as heretofore, the possibility of maintaining, by means of the rotation advocated, a milking cow throughout the year upon every acre of average good Western Oregon land, and furnishing a continuous supply of green feed cut from the field every day in the year, thus permitting the most intensive sort of dairy farming. Under this system of cropping, it is possible to obtain a profit of from $50 to $100 an acre from land handled in this way devoted to dairying, with careful utilization of the by-products—the skim milk for the pigs and manure for increasing fertility. Under this plan the rotation is about as follows:

Vetch and rye from April 15 to May 15.

Vetch and oats and clover from May 15 to July 15.

Corn silage from July 15 to August 15 or September 1.

Corn (green) from September 1 to October 15.

Kale and mangels, and if desired, silage, from October 15 to April 15.

The use of silage for midsummer is rather a novel practice, but highly successful here, and more needed indeed at that season than in midwinter, the time when silage is generally used elsewhere.

New trials of soiling crops undertaken were mixtures of ceraels and vetch compared with cereals alone and vetch alone. The cereals alone gave both poor yields and poor quality for soiling purposes, while the mixture of cereals and vetch proved the best in varying degrees, according to the mixture. One of the seedings of rye and vetch yielded 10.3 tons of green feed to the acre. Crimson clover gave 10 tons of green feed to the acre, immediately following the vetch and rye.

2. Fertility rotation. To get the large block of plots required for this experiment into a uniform state of fertility, it was necessary to crop the plots as uniformly as possible throughout, in the effort to get them equalized, so that these experiments when they are started will give conclusive results.

3. Experiment with Legumes. The variety trial of vetches to determine the best seed producers was not continued. The seed is in storage and the experiment will be continued as soon as conditions permit. The trial of vetches as forage producers is considered practically concluded, the smooth vetch (**Vicia sativa**) common to all Western Oregon, having proved itself without question superior to all other varieties for Western Oregon conditions.

Variety trials with field peas; breeding of **Vicia sativa** for high protein content, and the propagation and maintenance of alfalfa under Western Oregon conditions have been temporarily discontinued.

4. Soy Beans. The variety test of soy beans has given some promising results. The first trials were rather discouraging, but the later results have been a good deal better. Two varieties, the Chernie and Tashing, matured well, as did some of the selections from the previous year.

Experiments with Cereal Crops.

1. Breeding of corn for grain and forage production under Western Oregon conditions. Forty-four varieties have been tested, and as heretofore the Experiment Station selections of Minnesota No. 13 were best silage and forage producers, while selections of Minnesota 23 were the best grain producers. The second-best forage corn, as heretofore, was the Northwestern Dent, while Early Bird and Brown County Yellow Dent also gave excellent results.

The second-best grain producer was the Dakota Sunshine. As previously, ear-to-row tests of both the Number 13 and Number 23 were continued. From the Station No. 23, yields ranging from 34 to 85 bushels an acre were obtained. From the Station No. 13, silage yields running from 7.4 tons to 22.1 tons an acre were obtained.

2. Variety Test of Cereals. The variety test of winter grains was suspended. Thirteen varieties of spring oats were planted, the yield ranging from 33 to 50 bushels an acre. The leading varieties were Dow's Pedigree Banner, Improved American, Widmer Three-Grain, Shadeland Challenge, and Shadeland Climax.

Of the spring barleys, twenty-three varieties were tested, ranging in yield from 15 to 35 bushels an acre. The leading varieties were Number 19785, 19786, Oderbrucker, Common Beardless (Wertz), Wisconsin No. 6, and Wisconsin No. 13.

The best yielding and best quality of spring wheat was obtained from the Pedigree Red Fife.

Kale-Breeding Experiment. For the second time the much-advertised marrow cabbage was compared with the selected thousand-headed kale, but the latter proved decidedly superior and further test of the marrow cabbage is considered unnecessary.

As heretofore, a number of selections of kale were made, inferior plants were destroyed in the seed plots, and a high quality of seed produced. The Station kale seed is in wide demand throughout Western Oregon, as hundreds of cooperative trials in every section have demonstrated it to be superior to common seed.

Potato-Breeding Experiments. The variety trial included twenty-seven varieties and a considerable number of selections. The leading varieties so far are the selected Burbank, Bovee, and Gold Coin.

Experiment to determine the Value of Irrigation to Western Oregon Crops, such as Clover, Alfalfa, Corn, Mangels, Kale, etc. Six years' data

are available on eight different field crops, together with weather records and the results of several thousand soil-moisture determinations. Determination of moisture content of the soil and the evaporation from the water surface have shown themselves to be valuable guides as to the best time to irrigate. The results show that potatoes make a maximum yield if irrigated when the moisture content drops to twenty per cent in the first foot of soil, while with clover the most economical returns are had when it drops to fifteen per cent in the first two feet. The most economical returns for each unit of water applied have been secured from very light irrigations applied to soils of high fertility. Three 1-inch irrigations for potatoes gave 29 bushels for each acre inch. The effect of irrigation on the quality of potatoes was determined, showing no distinct effect as to edibility but a decided increase in the percentage of marketable potatoes where irrigation was used. Over-irrigation on the other hand caused an equally marked decrease in marketable quality.

A careful study of the effect of irrigation on the soil itself shows that with careful handling as to crop rotation, cultivation, and judicious use of water, the quality of the soil may steadily be improved, but with careless handling the quality may be greatly injured.

Using one dollar, which the data show is the maximum total annual cost for each acre inch, corn has given an average profit of 50 cents an acre inch, kale 75 cents, beets $1.18, alfalfa $1.75, beans $2.86, clover $2.87, carrots $3.74, and potatoes $7.63 for each acre inch of water applied. The mean profit for each acre inch as an average of all crops and including nearly 150 trials, has been $2.33. The average increase in yield by crops has been 54 per cent and the average depth of irrigation for each season 4.8 inches.

It is safe to say that this experiment proves conclusively that irrigation may be successfully and profitably practiced on those soils of the Willamette Valley which are well drained and properly managed as to rotation, cultivation, and limited use of water, particularly for such types of farming as intensive dairying, truck gardening, and hop growing.

A new test was started to determine whether electricity or gasolene is the better fuel for pumping. Although the gasolene proved somewhat cheaper for the actual cost, the saving of labor effected by electricity made this method the better of the two.

Rice-Growing Experiment. A test was undertaken to determine the practicability of growing rice under local conditions. All of the hardiest varieties which were furnished by the U. S. department of Agriculture were tried and all started well, but only a few plants in the entire lot got so far as heading out, and not a grain matured.

DEPARTMENT OF DAIRY HUSBANDRY.

Owing to the vast amount of work in dairy investigations which has been done by other experiment stations, thus in a measure restricting the field for technical work without duplication of effort, it was thought

best to confine the work of this Station to the study of more local problems.

1. **Silage and Kale Feeding.** The use of kale as a winter forage crop is a very common practice in Western Oregon. The large yields, palatability, and high protein content of the plant make it a most desirable forage. But there is much complaint over the matter of harvesting the crop in all sorts of winter weather, and of the resultant effect on the soil. Besides, the high protein content of the plant, when fed in conjunction with other highly nitrogenous plants, gives a ration containing an excess of protein. Some progress has been made with this investigation, but sufficient data have not been secured to warrant conclusions.

Soiling experiments have been continued, and it is contemplated to undertake an investigation of incomplete as compared with complete soiling systems. It is generally recognized that the soiling system is essential to the highest success on high-priced lands, but it has not been proved that the best results in milk and fat production with the individual cow can be obtained year after year under the complete soiling system.

2. **Advanced Registration.** The testing of dairy cows for advanced registration is supervised by the various experiment stations in the states where the animals tested are located. During the year 1912-13 the time of one man has been practically all occupied with this work, and considerable additional time of special testers has also been required. While all expenses of the tester are met by the parties for whom the work is done, considerable time is required in checking and verifying the tester's figures. Ten breeders of Jerseys have been testing for yearly fat estimates, and four Holstein breeders have made seven-day tests during the year.

3. **Grade Herd Investigations.** Cooperative work has been taken up with three different owners of good grade herds. Tests of these animals are made monthly and the owner keeps daily records of milk production, as well as data on amount and value of feed.

BRANCH EXPERIMENT STATIONS.

Burns Station. This farm is thoroughly established, with modern buildings and good equipment for work. The present year, being the first season, has been devoted to summer fallowed land under different methods of cultivation. Forty to fifty plots, however, were seeded, largely with the idea of showing the futility of attempting to secure a crop without the storage of a year's moisture. Yields of grain running from five to fifteen bushels were obtained, but in the main it was demonstrated that summer fallowing was necessary before a profitable crop could be grown. Eleven different varieties of the hardiest strains of alfalfa that could be found were seeded and showed conclusively that the most frost-resistant and the most vigorous variety was the Baltic. The Grimm proved to be the second best.

In the fall of 1912, summer fallowed land was seeded to all varieties of winter crops, and full experimental work started at that time. The following spring, all spring varieties, including a very large trial of field peas, were planted, and further extensive seedings of alfalfa were made. Plantings on the eight substations throughout Harney county have been started and a number of cooperative trials with farmers have been inaugurated.

One of the most remarkable results obtained at the Burns Station this year is the effect of the cultivation methods employed for moisture conservation and the deep storage of moisture. Practically all Central Oregon is underlaid at a depth of twelve to eighteen feet with a water-carrying strata. To farmers in that section has been suggested the possibility, by careful conservation of the precipitation, of bringing the surface moisture in conjunction with the capillary moisture rising from the water table. Borings have been made throughout the year and a number of wells dug purposely to observe this moisture movement. These examinations revealed the fact that on more than fifty per cent of the 200-acre farm, where thorough cultivation has been given, the surface moisture has already joined the moisture from the water table, while in the remainder of the farm, as a result of tillage methods, the two moisture areas are rapidly drawing closer to each other. This phenomena will practically convert a dry farming area into a sub-irrigated area. Since it is estimated that there are about 2,000,000 acres of tillable land in Central Oregon, having practically the same condition as the farm at the Burns Station, the value of this discovery is obvious. The process of connecting up the two moisture areas has continued during the winter, and in the spring of 1913 borings indicated that fully 80 per cent of the area of the farm was moist from the surface all the way down to the water table.

Moro Station. Cooperative work with the U. S. Department of Agriculture at the Dry Farming Substation at Moro has been continued as heretofore. The permanent plan of work as already reported has been continued except that more space has been allotted to field peas, alfalfa, and other diversified crops.

Field peas grown in double drill rows, 35 inches apart, gave yields as high as 26 bushels an acre, which at 3 cents a pound (the local price) gave a return of $46 an acre, at no greater cost of production than wheat, which gives an average return in that district of $15 an acre. Field peas, however, may be grown every year, whereas wheat gives the return named only every other year; further, the field pea increases fertility while the wheat decreases it.

Good results have been secured from alfalfa, a yield of one ton of hay to the acre being recorded, and the promise of abundant seed production is assured.

The results from the tests of a large number of varieties of cereals, including both winter and spring varieties of wheat, barley, oats, and emmer, are good in practically every case, showing the marked superior-

ity of the Station varieties over those locally grown, the difference in yield in favor of the best Station varieties running anywhere from three to six bushels.

Excellent results were obtained from corn, the Station varieties proving the best, as heretofore.

Pasturing off field peas with hogs also proved a successful experiment, and one of widespread value. The pasturing off of corn with hogs is to be undertaken next year.

The complete list of experiments previously outlined, aggregating some five hundred different trials, will be continued the coming year.

Umatilla Station. A fairly complete report of the work of this station and the Southern Oregon Station at Talent is published in Station Bulletin No. 115; hence a list only of the principal problems under investigation at these stations will be included in this report.

At the Umatila station investigations have been undertaken in such problems as the clearing and leveling of new land; when to clear land; how to clear and level; applying irrigation; flumes and ditches; soil fertility; variety tests of fruits including the apple, pear, quince, prune, plum, cherry, nectarine, peach, apricot, and cane fruit, including currants, gooseberries, raspberries, dewberries, blackberries, loganberries, and other fruits and vegetables, including grapes, strawberries, asparagus, rhubarb, melons, potatoes, corn, eggplant, peanuts, and tomatoes. Experimental investigations have also been carried on in respect to cover crops, including field peas, vetch, espercett, red clover, sweet clover, alfalfa, crimson clover. Other forage crops tested were Kaffir corn, milo maize, sorghum, and millet.

Various phases of irrigation were studied, soil-moisture determinations made, trees for wind-breaks and ornamentals were tested, forest plantings and meteorological observations were also made.

Southern Oregon Station. The work reported last year has been continued and the most important new work is the very large planting of foreign pears, representing nearly 500 varieties. The purpose of this work is to secure stocks which are resistant to fire blight, and by means of selection and cross pollination it is thought possible to obtain good varieties of commercial pears that may also be resistant to blight.

Hood River Station. The work of the Hood River Station is well established, and laboratories are fairly well equipped for the investigations. The major work of this station is an investigation of what is commonly known as fruit pit or core rot. Work on the problem of fruit pit and winter injury is conducted cooperatively between the departments of Plant Pathology and Horticulture. In addition to the problems mentioned, apple scab, irrigation, some fruit pests, and orchard cover crops, are under investigation.

PUBLICATIONS.

Following is a list of the publications which have been issued during this biennium:

Bulletin No. 110—Preliminary Frost Fighting Studies in the Rogue River Valley.

Bulletin No. 111—Orchard Management.

Bulletin No. 112—The Soils of Oregon.

Bulletin No. 113—Orchard Irrigation Studies in the Rogue River Valley.

Bulletin No. 114—Hop Investigations.

Bulletin No. 115—Biennial Report of the Division of Horticulture.

Research Bulletin No. 1, Part 1—The Pollination of the Pomaceous Fruits.

Circular Bulletin No. 20—The Pollination Question.

Circular Bulletin No. 19—The Trap-Nest.

Circular Bulletin No. 18—The Hog and Field Pea Special—Swine Husbandry.

Biennial Crop Pest and Horticultural Report.

Respectfully submitted,
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Director, Oregon Experiment Station.

July 1, 1914.